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Wind energy development in Pakistan

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Abstract

Pakistan has a very limited fossil fuel resource base. The poor economy does not allow the import of fossil fuels, particularly oil, on a large scale. Moreover, too much reliance on imported oil is critical from energy security point of view. A large fraction of the population lives in remote areas and is still waiting to be connected to the national electricity grid. To help these remote communities in particular, and to overcome energy shortages in general, Pakistan needs to develop its indigenous energy resources like hydropower, solar and wind. More than 1000 km long coastline in south and some places in northern mountainous areas provide an excellent resource of wind energy. This vast potential can be exploited to produce electricity on both community and wind farm scales. Applications other than electricity production, such as water pumping, also have vast applications. This article discusses the past, the present and the future of wind energy use in Pakistan. The efforts for the utilization of wind energy in the country are presented as well, along with barriers to its development. It is concluded that the potential exists, but significant efforts are needed to effectively make use of this cheap renewable energy source.

Keywords: Wind energy; Pakistan

Contents

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1. Introduction

Energy is a key infrastructural requirement for the modern industrial economy. Energy provides an essential ingredient for almost all human activities: it provides services for cooking and space/water heating, lighting, health, food production and storage, education, mineral extraction, industrial production and transportation. Modern energy services are a powerful engine of economic and social development, and no country has managed to develop much beyond a subsistence economy without ensuring at least a minimum access to energy services for a broad section of its population.

Historically, Pakistan has been an energy-deficient country. It has relied almost exclusively upon fossil fuels and hydroelectricity as its primary energy supplies. Because of fast-growing economy and population, the demand of energy is rapidly increasing. Pakistan is in danger of facing huge energy deficits in the coming years and even at present, the primary energy supplies are not able to meet the existing demand in a proper way. Pakistan faces an era of increasing use of renewable energy sources, which will require the development of fundamental knowledge on wind energy to use this clean and affordable energy source efficiently.

This article will discuss the status and outlook of wind energy use in Pakistan. The following sections describe geography of Pakistan, existing energy situation and the status of wind energy use in the country followed by a perspective on policy and planning.

2. Geographic profile of Pakistan

Pakistan is situated between latitude 24 and 37 degrees North and longitude 62 and 75 degrees East. The country borders India in the east, Iran on the west, China in the north, Afghanistan in the northwest and the Arabian Sea in the south. A country map is shown in Fig. 1. The total area of Pakistan is 8,03,950 km^2, which includes Federally Administered Tribal and Northern Areas (FATA and FANA). The country is divided into four provinces, namely North-West Frontier Province (NWFP), Punjab, Sindh, and Balochistan. The great mountain ranges of the Himalayas, the Karakorams and the Hindu Kush form Pakistan's northern highlands of NWFP and the Northern Areas. Punjab province is



Fig. 1. Map of Pakistan (source: http://www.lib.utexas.edu).

a flat, mostly an alluvial plain, with five major rivers dominating the upper region eventually joining the Indus River flowing south to the Arabian Sea. Sindh is bounded on the east by the Thar Desert and the Rann of Kutch, and on the west by the Kirthar range, while the Balochistan Plateau is predominantly an arid tableland, encircled by dry mountains [1].

Pakistan's coastline is about 1046 km long, extending from Indian border in the east to the Iranian border in the west [2].

3. Current energy situation

Fig. 2 shows a graphical representation of Pakistan's primary energy supplies. Pakistan's energy mix is highly dependent on fossil fuels, i.e. oil, liquid petroleum gas (LPG), natural gas and coal, that account for 86.5% of the total primary energy supplies of 50.819 million tonnes of oil equivalent (MTOE). Nuclear energy has a share of 0.8% and the remaining 12.7% is supplied by hydroelectricity [3].

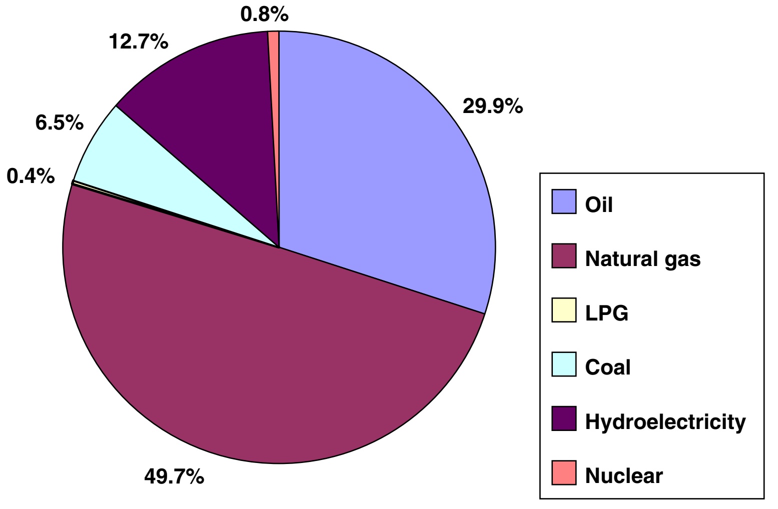


Fig. 2. Primary energy supplies by source (source: Pakistan Energy Yearbook, 2004).

Pakistan currently produces around 64,000 barrels of crude oil per day. The consumption of petroleum products during 2005 is estimated at 351,400 barrels per day. With proven reserves of just 28.8 million barrels [4], Pakistan is never expected to be self-sufficient in oil. The high dependence on oil imports has a huge negative impact on economy and energy security of the country. The natural gas reserves are not in great position either, with proven reserves of 28.62 trillion cubic feet (Tcf). During 2003–2004, production was around 1.2 Tcf [3]. At this production level, Pakistan's known reserves would finish in 24 years. This is an optimistic figure keeping in view that Pakistan currently ranks third in the world in use of natural gas as a transport fuel [4], and Government is making every effort to expand this use. The measured coal reserves are in large quantity (3303 million tonnes). However, currently coal is not playing a noticeable role in Pakistan's energy mix. The domestic production of coal was only 3.3 million tonnes per year during 2003–2004 [3].

4. Wind as a source of energy

The power of the wind has been utilized for at least the past 3000 years. Until the early 20th century, wind power was used to provide mechanical power to pump water or to grind grain, and that was the time when the first wind turbines for electricity generation were developed. The technology was improved step by step since the early 1970s. By the end of the 1990s, wind energy re-emerged as one of the most important renewable energy resources. During the last decade of the 20th century, worldwide wind capacity has doubled approximately every 3 years. At present, wind power plants, wind-pumps and windmills are being successfully operated in many countries around the world. The costs of electricity generated from wind power has fallen to about one-sixth since the early 1980, and the trend seems to continue [5].

Wind energy is currently viewed as one of the most promising renewable energy sources. The use of wind energy has no toxic emissions and without any surprise, wind energy is the fastest growing renewable energy source in the world.

5. Renewable energy in Pakistan: Institutional infrastructure

In Pakistan, nearly all the R&D work in the field of renewable energy is carried out by public sector organizations because of the lack of such capabilities in the private sector. The public bodies engaged in research in the field of renewable energy technologies in the country are described below.

5.1. Pakistan Council for Renewable Energy Technologies

Pakistan Council for Renewable Energy Technologies (PCRET) was established in 2001 by merging National Institute of Silicon Technology (NIST) and Pakistan Council for Appropriate Technologies (PCAT). This was done to achieve a better coordination of activities and to avoid duplication of research. The council has its head office at Islamabad, the federal capital, and four regional/field offices in the provincial capitals, i.e. Peshawar, Lahore, Karachi and Quetta. PCRET has been assigned the responsibility to coordinate research and development activities on renewable energy technologies in the country, particularly in the areas of microhydel power plants, biogas, fuel-saving technologies, solar thermal appliances, photovoltaics and wind energy [1]. PCRET is a relatively new organization. Its predecessors, NIST and PCAT, were concentrating on research and development in solar energy in general and photovoltaics in particular, microhydropower plants, biogas plants, harnessing wind energy for water pumping, and energy-efficient cooking stoves.

5.2. Alternative Energy Development Board

The Government of Pakistan created the Alternative Energy Development Board (AEDB) in May 2003 to act as the central national body on the subject of renewable energy. The main objective of the Board is to facilitate, promote and encourage development of renewable energy in Pakistan with a mission to introduce alternative/renewable energy at an accelerated rate to achieve 10% share of RE in the energy mix of the country by 2015 [6]. Among other targets of AEDB, the noticeable are: (1) 2% of investment made in power sector should be dedicated to development of alternative/renewable energy technologies base in Pakistan, (2) all localities not planned/anticipated to be connected with national grid in next 20 years are to be earmarked for alternative/renewable energy resources, and (3) all solar/wind energy-related technologies would be indigenized in the next decade through national/international collaboration [7].

6. Wind power activities in Pakistan

In Pakistan, the potential of wind power has so far not been utilized significantly. There was a lack of reliable and complete data on wind resources in Pakistan until very recently.

Although, limited daily and monthly wind velocity data were available with the Pakistan Meteorological Department (PMD) for different airports of the country, it was unreliable and insufficient for assessing the technical feasibility and economic viability of a wind power project. Nonetheless, it gave an idea about the sites where wind power potential could be harnessed. It was believed that, wind regimes in the coastal areas of Sindh and Balochistan, some parts of the mountainous north, and the Indus valley, may have adequate wind velocities for enough duration to be usable [8]. The possibility of exploiting the wind potential in gorges and valleys throughout the Hindu Kush-Himalayas (HKH) region has also been highlighted in the literature elsewhere [9].

The country has been slow in adopting the wind energy technology. Two units of 1 and 10 kW electric supply have been installed in Balochistan and Sindh, respectively [10]. PCAT installed more than two dozen imported and locally made windmills for pumping water at many locations in Sindh and Balochistan. The experiment suffered due to low-quality mills and lack of proper infrastructure for maintenance [11]. A local manufacturer (Merin Ltd., Karachi) is making windmills that lift 10,000–22,000 gallons of water per day from a depth of 70 ft. The manufacturer claims to have exported windmills and installed 24 of these locally. Some of these were supplied to Abu Dhabi and installed in the desert areas to supply drinking water for human and animals [12].

In March 2001, a report on wind-mapping of Pakistan was submitted to PCAT by Khan [13]. This was based on the wind speed data collected by PMD over the last 50 years. The data was recorded at 50 stations all over Pakistan at 2–10 m anemometer height, which is not sufficient to adequately assess the wind potential at a site. Wind speeds at 30 m were simulated using this data and wind mapping was done. The results obtained were promising. In another report [14], Khan identified Chor, Badin, Hyderabad and Karachi as among the best sites in Pakistan for utilizing wind for power generation or water pumping.

In the year 2002, 14 small wind turbines, six of 500 W each and eight of 300 W each, were procured from China and installed by PCRET for demonstration purpose. Out of these, eight were installed in the coastal belt of Balochistan and six in the costal areas of Sindh. This demonstration project has been concluded successfully. It has been observed that small wind turbines are both technically and economically viable for electrification of the remote communities. PCRET is now installing 120 small wind turbines in an ongoing project. Efforts are also underway to initiate local manufacture of 500 W wind turbines under transfer of technology from China, and 5–10 kW turbines under transfer of technology from some European countries [15–17].

Empower Consultants of New Zealand have completed a community-owned and managed wind-diesel hybrid electrification project in Durgai village, District Sibi, Balochistan, on the request of Pakistan Agricultural Research Council (PARC) [18]. The Asia Development Assistance Facility of the New Zealand Agency for International Development provided the financial support for this demonstration project. The project commenced in March 2001, simultaneously with the solar-diesel hybrid, mentioned elsewhere [1]. Design of an energy generation, storage and distribution system was undertaken when technical and financial feasibility was established after 12-month wind speed data collection. The system was commissioned in September 2003, comprising

7.5 kW wind turbine, 500 W solar panels ensuring the battery charge (supplied and installed by the PCRET), with a back-up diesel generator and 125 kWh battery bank. Tariff setting, management and consumer training, technical training and support, power utilization and demand-side/supply-side management models formed an integral part of the project. The project is aimed at establishing a model for remote communities to operate their own power utilities in a sustainable way, and to replicate the project in a programme involving community contribution, government and donor funding agencies. A monitoring mission comprising representatives of project sponsors, PARC, EMPOWER and local community-based organizations (CBOs) went to the field in February 2004, 5 months after commissioning, and found out that project had been functioning smoothly and it was a total success story.

Ministry of Environment, through a US$471,900 support from the Global Environment Facility (GEF), Nordic Trust Fund, and UNDP, initiated a project entitled Commercialization of Wind Power Potential in Pakistan [19,20]. The project is aimed at determining the feasibility for the country's first wind power project in the southwestern coast of Balochistan. The town of Pasni along Makran coast was selected for this study. Wind speed measurements were started in early 2002 and continued for 20 months. This project later became part of a new comprehensive project named Sustainable Development of Utility-scale Wind Power Production, Phase 1. With a total financing of US$4,195,931, it was scheduled to commence in July 2004 tentatively [21]. Phase 1 will take 2 years to complete and if the outcomes are positive, then Phase 2 would be initiated. In Phase 2, a 15-MW wind farm would be developed over a 3-year period, which would be connected to the isolated small Makran grid.

PMD has conducted the yet most-detailed study of the wind source potential in Sindh and Balochistan, mostly in coastal areas [22]. Ministry of Science and Technology of the Government of Pakistan provided the required funding for this project. PMD set up 45 measuring stations across the two provinces for this 24-month study. It has helped to identify the potential areas where economically feasible wind farms can be established. It has been found that, contrary to the general impression, Sindh coastal areas have greater wind power potential than Balochistan coastal areas. Potential areas in Sindh cover 9749 km^2 with an average capacity factor of 25%. The gross wind power potential of this area is 43,871 MW, and keeping in view the utilization constraints, the exploitable potential is estimated to be about 11,000 MW.

AEDB has approved New Park Energy (NPE), Phase I, a 400-MW wind project near Port Qasim. General Electric (GE) Energy will supply 30 of their 1.5-MW turbines. The project is to be developed in 45 MW increments [4,23–25].

Various news reports inform that 28 international companies from Brazil, Canada, China, Denmark, Holland, Germany, Malaysia, Spain, USA, etc., have been issued letters of interest by the AEDB to invest in the wind power generation projects of about 50 MW each. Wind power projects of total 100 MW are being established on built-own-operate-and-transfer (BOOT) basis at Gharo and Keti Bundar in Sindh. Though the projects have already run into snags and delayed by 1 year, they are now scheduled to go on stream, partially, of 45 MW capacity (30 units of 1.5 MW capacity each), by June 2006. The Government of Sindh has earmarked over 12,000 acres of land for wind farms. In accordance with the policy directives of the Government of Pakistan, WAPDA and Karachi Electric Supply Corporation (KESC) will purchase all the power generated from the wind projects [26–33].

7. Policy perspectives

In 2002, the government announced policy for power generation projects according to which 500 MW of installed capacity will be achieved through renewable energy in the medium term, while for the long term, the target is an additional 1000 MW [34].

On 15 February 2005, the President and Prime Minister of Pakistan approved an action plan to meet growing energy requirements in immediate, medium-term and long-term perspectives [30,35]. The plan is called Energy Security Action Plan and is a classified government document [36]. It was decided to establish a pilot project based on wind energy on fast-track basis for generation of 100 MW of wind power by December 2005. This project has been delayed and is now expected to start generation in June 2006 as depicted earlier in this article.

The Medium-Term Development Framework (MTDF) 2005–10 announced by the Government of Pakistan in May 2005 places a special emphasis on renewable energy development [37]. It stipulates AEDB to facilitate alternative/renewable energy projects, and to develop and implement off-grid electrification programme for rural areas. The plans asks for installation of 100 MW wind power by December 2005 at Kati Bander and Gharo, Sindh (as has been described above as well), and for development of 700 MW renewable power by 2010. The target for 2030 is at least 9700 MW, which would be 5% of the total planned national power generation capacity at that time. In addition, under the remote village electrification programme, 54,000 homes would be lit by solar/wind/microhydro-power during the MTDF.

Very recently the Government of Pakistan has issued two long-awaited policy documents viz. Guidelines for Determination of Tariff for Wind Power Generation—Year 2006, and Policy for Development of Renewable Energy in Pakistan—2006 (draft) [38,39].

8. Existing barriers to wind energy development

While the benefits of tapping the available renewable resource potential in the country as a low-cost, clean option have long been recognized in strategic planning, specific steps for promoting and developing these small-scale options have not been given due priority in the face of more pressing concerns with the overall national energy situation. Barriers to investment and adoption of renewable energy on a national scale can be classified broadly into several main categories, namely those that relate to policy, institutional, regulatory, fiscal, and technical information issues. This section outlines these barriers, with details can be found elsewhere in the literature [40].

8.1. Policy barriers

Despite the development of a number of energy policies and plans, the priority accorded to the renewable energy sector in Pakistan remains low. While the acknowledgement of renewable resources as an alternative source of energy has prevailed in most of the policy and plan documents, little substantive action has been taken for their meaningful development, and almost no specific incentives have been offered to encourage the nurturing of a full-fledged industry based on these technologies. While broad goals and potential projects for the development of renewable resources have been outlined under

various government plans, there has been little accompanying support available for their realization. Within the various power policies that have attempted to restructure the power sector and promote private power investments over the years, so far no special efforts have been made to attract financing for renewable technologies [40].

8.2. Institutional barriers

Renewable energy research, development and implementation in Pakistan, have been hampered by a lack of institutional support and poor definition of mandates and responsibilities amongst those organizations that do exist for the purpose. Before the creation of AEDB, there was not a single agency with the overall responsibility for policy and planning advice, and strategic management of the sector, and there were a number of disparate bodies set up with limited objectives and there was little coordination amongst different players. As a result, the few initiatives taken, principally with respect to biomass, solar and wind energy applications, have not been able to progress beyond the pilot or technology demonstration phase. Because of the absence of a systematic approach to renewable resource deployment, local community-level and distributed energy demand and supply options have not been properly assessed, aspects where renewable energy options can offer attractive applications, nor has the commercial exploitation of renewable power been properly evaluated, which would involve coordinating with agencies and utilities involved in such operations. The impact of such weak institutional arrangements has been to further marginalize renewable options, instead of finding ways of incorporating these into the mainstream energy planning and supply mechanisms [40].

8.3. Regulatory barriers

Regulatory barriers to private power generation are being gradually addressed in Pakistan through new institutional arrangements, although these would require further time and effort to become truly effective. However, incorporating improved regulations pertaining to commercial renewable energy projects would be necessary for protecting the interests of this new industry and to level the field vis-à-vis more entrenched competitive generation technologies [40].

8.4. Financial barriers

Financial and fiscal incentives, or lack thereof, can play an instrumental role in attracting or discouraging private investment in new technologies, such as wind and solar power. The Government of Pakistan must devise a fiscal regime specifically for commercial renewable-resource-based power generation, similar to the one it successfully implemented for thermal, and later hydel, projects in the country [40].

8.5. Information and technology barriers

A lack of general awareness, technological knowledge, and detailed information on the available renewable potential and energy markets in the country seriously impedes consideration of alternative energy options in the decision-making process, at both the national policy-making and investor-planning levels. Many mature technologies, such as

wind power, and suitable areas of applications, especially in remote locations, have not been properly assessed for implementation in Pakistan because of ignorance of relevant technical and cost considerations or the absence of sound data on which to devise renewable energy solutions. Thus, the need for increasing the availability of technical information, education, and data collection on local conditions and resources, has been identified as a way of facilitating an improved appraisal of renewable energy options, and wind power in particular, in Pakistan [40].

9. Conclusion and recommendations

Pakistan has undoubtedly significant potential for harnessing wind energy. Small-scale applications include water pumping and providing electric power to remote off-grid communities. Large grid-connected wind farms can help alleviating power shortages in general. The living standard will go up and environment quality will improve with the development of wind energy resource. The reliance on imported oil will decrease, which, in turn, will enhance the energy security of the country. Well-organized and concerted efforts need to be made by the government to promote the use of wind energy and to educate people about its associated benefits. The following measures are especially recommended in this regard:

1. The national energy policy should include long-term strategies to promote the use of wind energy technologies.
2. Adequate funds for R&D and for transforming lab-scale products into commercial products should be provided. University students should be encouraged to conduct research projects in wind energy.
3. Entrepreneurs should be motivated through policy initiatives such as tax breaks, reduction/exemption from import duties and taxes.
4. End users should be provided soft loans/subsidies.
5. Funds for wind energy demonstration community projects should be provided. Small wind turbines for water pumping should be made available to the remote communities at economical rates.
6. Policies must be made to ensure that foreign investors transfer the know-how for fabrication of wind turbines to Pakistani counterparts.
7. International cooperation should be actively sought after for proper training of local manpower.

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